RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS (DO-282), Revision A

Meeting #15

Determining UAT Transmitter Equipage

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SUMMARY

This Working Paper presents the preliminary results of an investigation into a possible method of determining the equipage of a UAT transmitter solely by collecting information on received message types. The simulation was performed for the Core Europe 2015 scenario using the Multi-Aircraft UAT Simulation (MAUS).

Determining Transmitter Equipage

Below are the preliminary results of an investigation into a possible method of determining the equipage of a UAT transmitter solely by collecting information on received message types. The simulation was done for the Core Europe 2015 scenario using the Multi-Aircraft UAT Simulation (MAUS).

- A0/A1L equipages are identified by successful receipt of message type 2*.
- A1H equipage is identified by successful receipt of message types 3* or 6*.
- A2 equipage is identified by either:
    - Three seconds of consecutive type 4* messages, or
    - Successful reception of a message type 4* AND a message type 1*. The type 4 message indicates that the transmitter is equipage A3 or A2, and the type 1 message will indicate whether or not the transmitter is an A3.
- A3 equipage is identified by the successful reception of either message type 1* (with the appropriate capability code information set) or message type 5*.

Figures 1 and 2 below show the mean time to identify transmitters as a function of range for a high altitude A3 and A2 receiver, respectively, in the Core Europe 2015 scenario, by transmitter equipage type. Figures 3 and 4 are the maximum times to identify the transmitters.

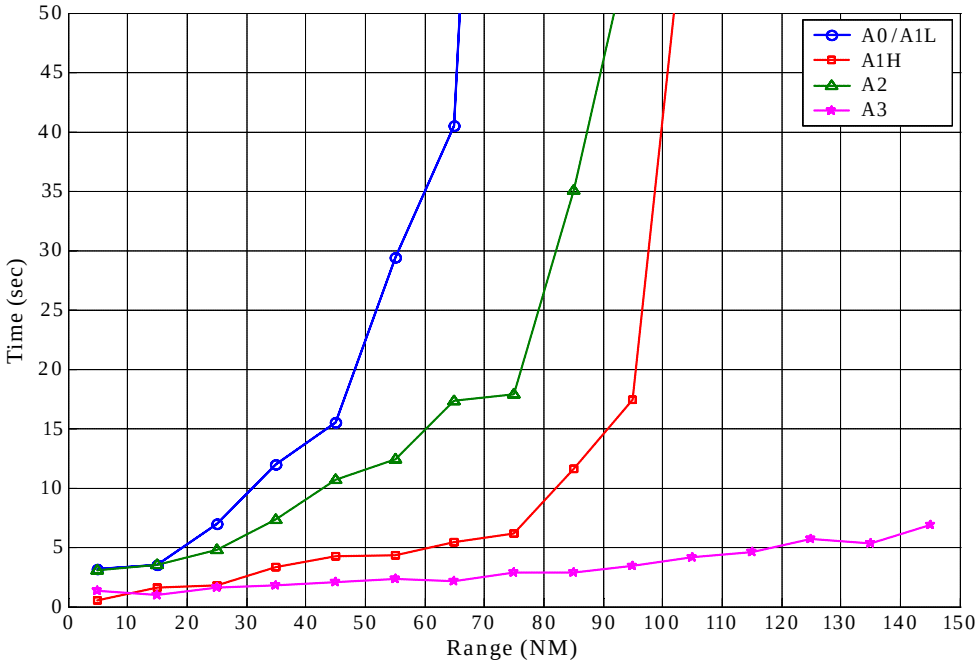

Figure 1 - Average Times for an A3 Receiver at High Altitude in CE 2015 to Identify Transmitter Equipages

* payload types as defined by DO-282 on page 27

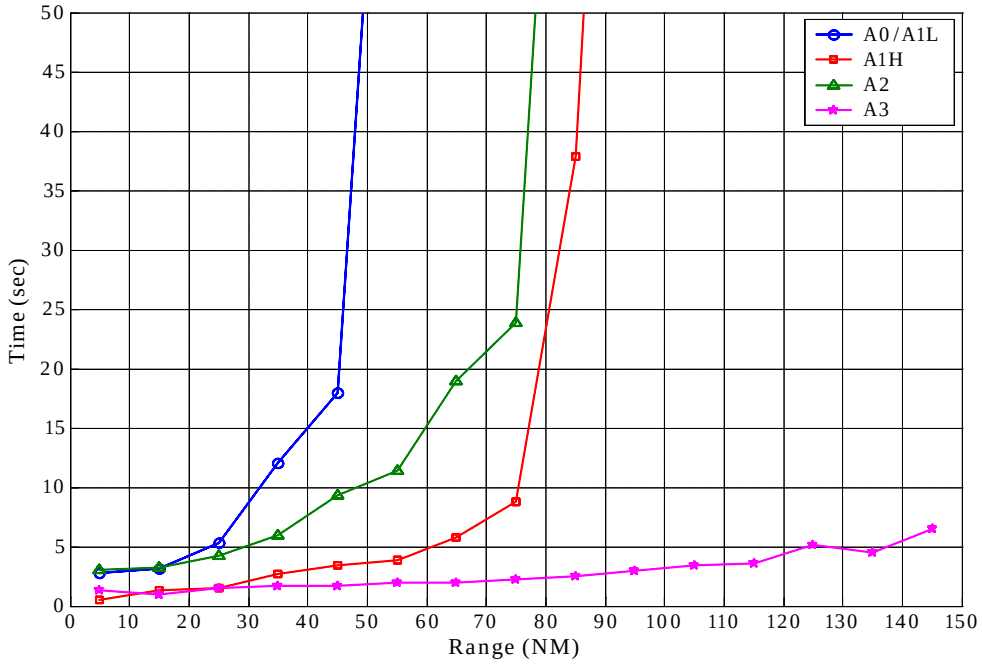

Figure 2 - Average Times for an A2 Receiver at High Altitude in CE 2015 to Identify Transmitter Equipages

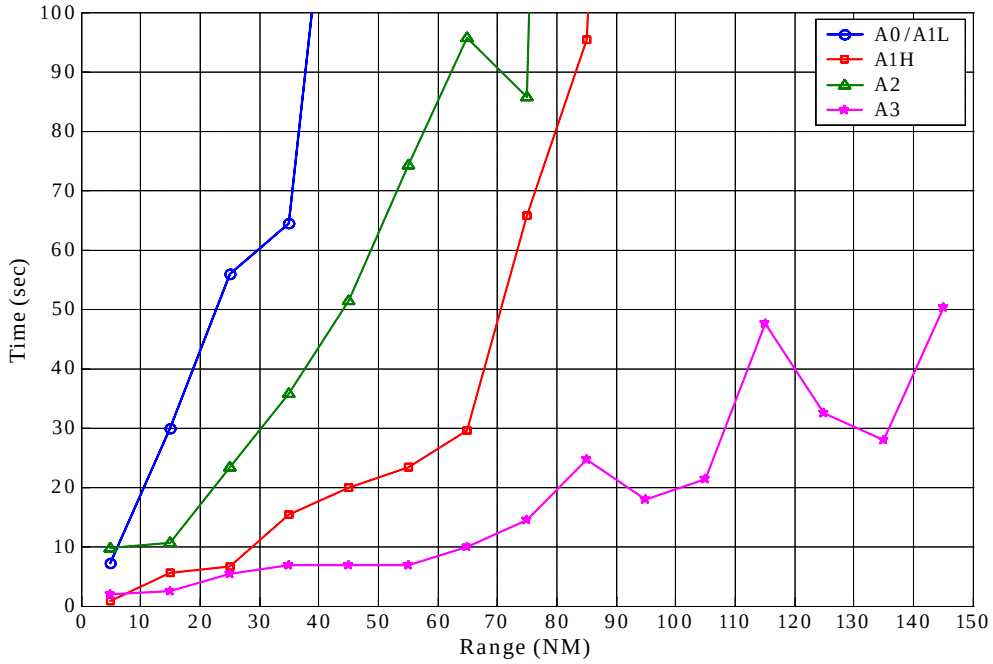

Figure 3 – Maximum Times for an A3 Receiver at High Altitude in CE 2015 to Identify Transmitter Equipages

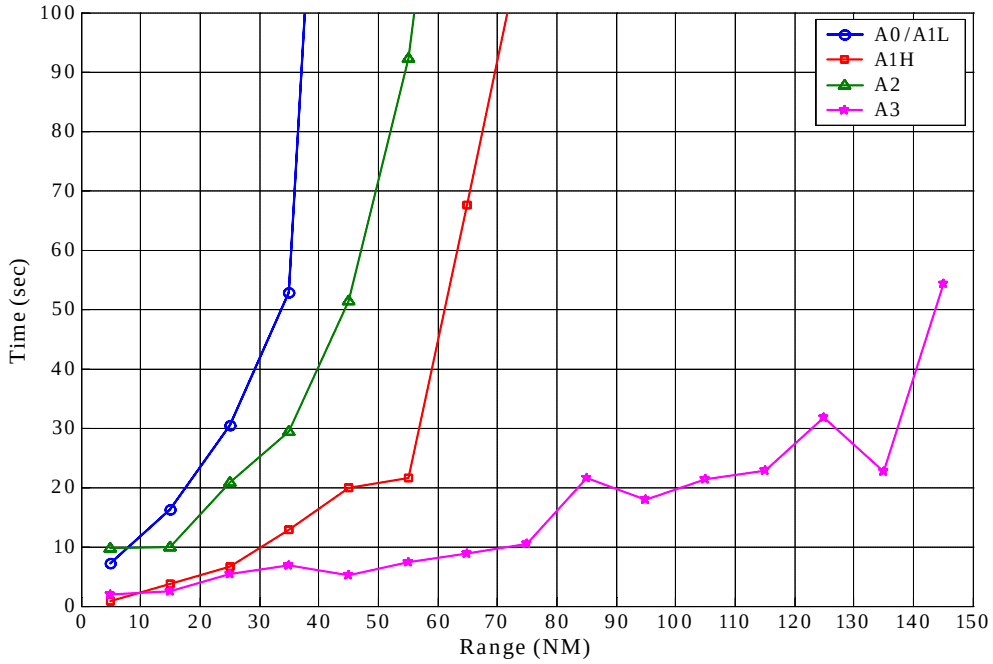

Figure 4 - Maximum Times for an A2 Receiver at High Altitude in CE 2015 to Identify Transmitter Equipages

Features of the performance of the algorithm may be summarized as follows:

- A3 equipage is identified on average in less than 10 seconds out to 150 NM. In the worst case, they are identified in 25 seconds or less out to 100 NM, and less than one minute out to 150 NM.
- A2 equipage is identified on average in 25 seconds or less out to 80 NM. The worst-case time is less than 1 minute out to 50 NM.
- A1H is the second easiest equipage to identify, after A3, since three out of every 4 messages uniquely identify this equipage. Transmitters less than 80 NM away are identified on average in under 10 seconds, and the worst-case identification out to 60 NM is less than 30 seconds.
- A0/A1L are hampered by the transmit power and only have a limited range. They have the greatest times for identification of the aircraft equipages.

Unidentified Equipage Analysis

Figure 5 shows the fraction of unknown transmitter equipages by transmitter equipage type for the case of the A2 receiver at high altitude. No A3's out to 150 NM (the cutoff) were unidentified.

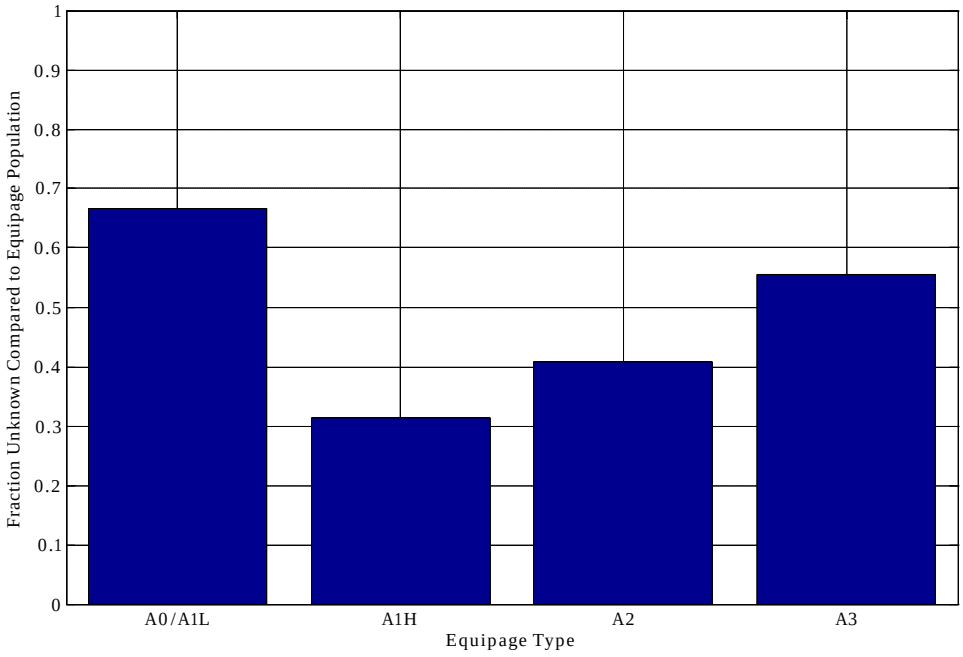

Figure 5 - Fractions of Transmitters Not Identified in CE2015 by a High Altitude A2 Receiver

Figure 6 shows the fraction of unknown transmitters as a function of range from an A2 receiver. No aircraft are unidentified at 60 NM or less. There are no unidentified A1H's at ranges less than 100 NM, and no A3's are unidentified.

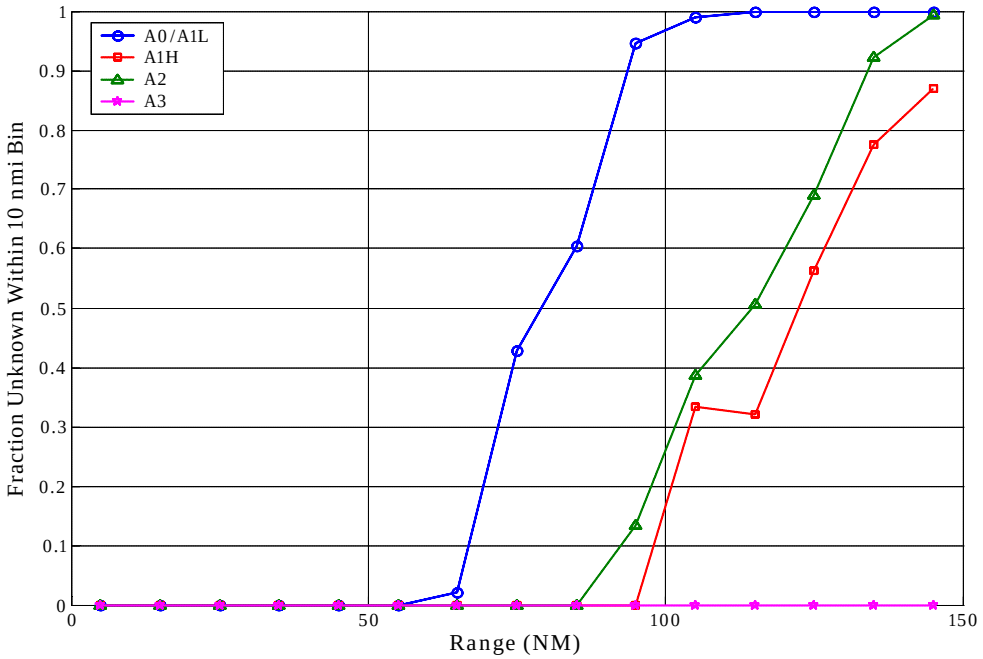

Figure 6 –Fraction of Unknown Transmitter Equipages by Range for CE 2015 for a High Altitude A2 Receiver

Receiving Aircraft on Ground

Figures 7 – 10 show the mean and maximum times to identify aircraft, similar to Figures 1-4, but for a receive aircraft on the surface at Brussels. These aircraft on the ground have, in addition to fewer aircraft within the line-of-sight, no interference from DME ground stations or onboard DME pulses. As a result of the reduced interference scenario, the times to identify the various classes of aircraft are slightly reduced.

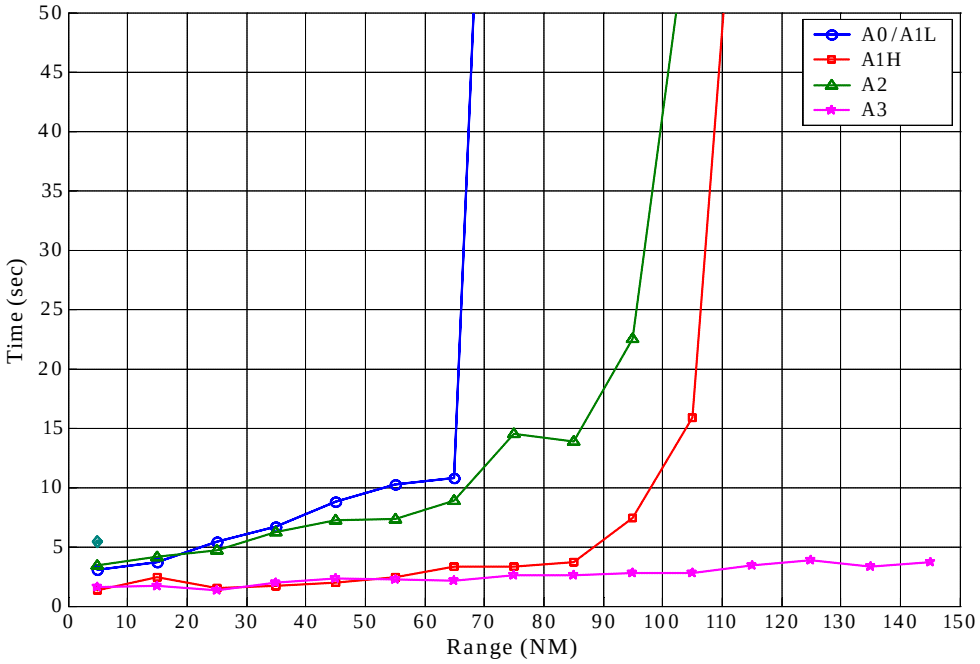

Figure 7 - Average Times for an A3 Receiver on the Surface at Brussels in CE 2015 to Identify Transmitter Equipages

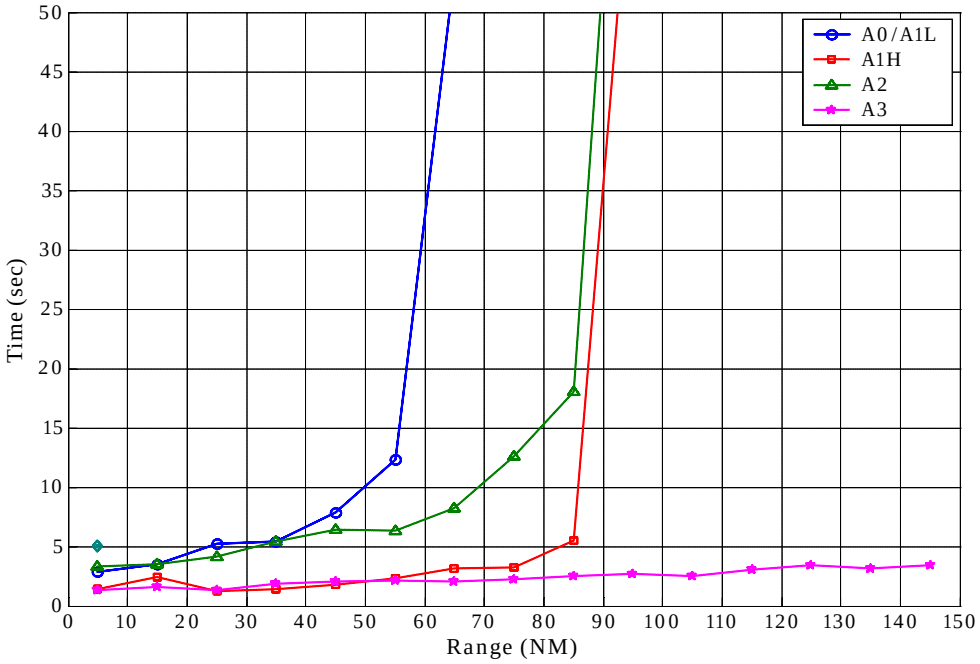

Figure 8 - Average Times for an A2 Receiver on the Surface at Brussels in CE 2015 to Identify Transmitter Equipages

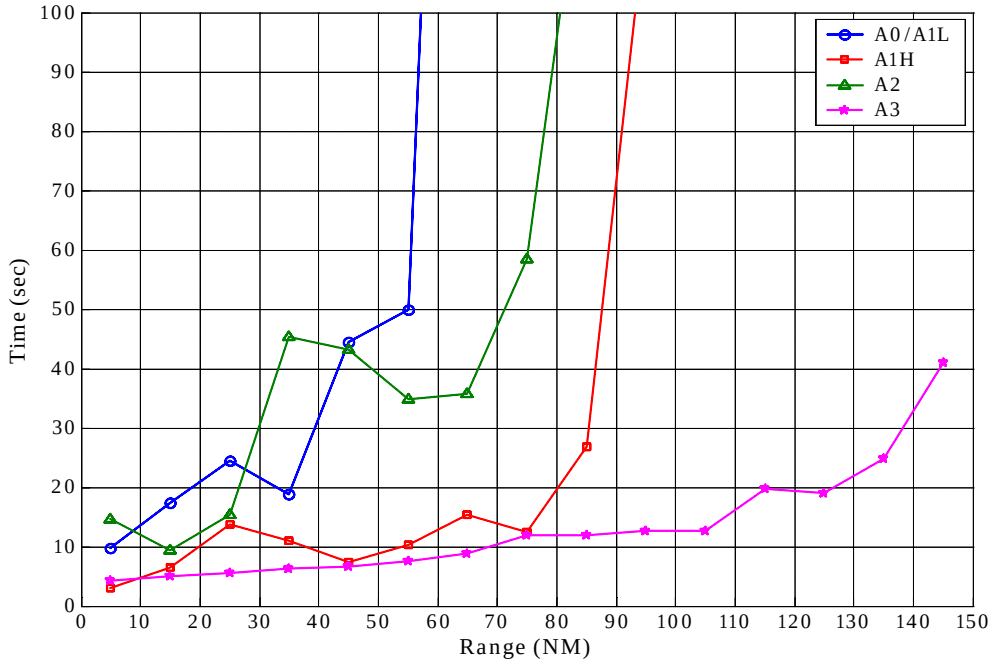

Figure 9 - Maximum Times for an A3 Receiver on the Ground at Brussels in CE 2015 to Identify Transmitter Equipages

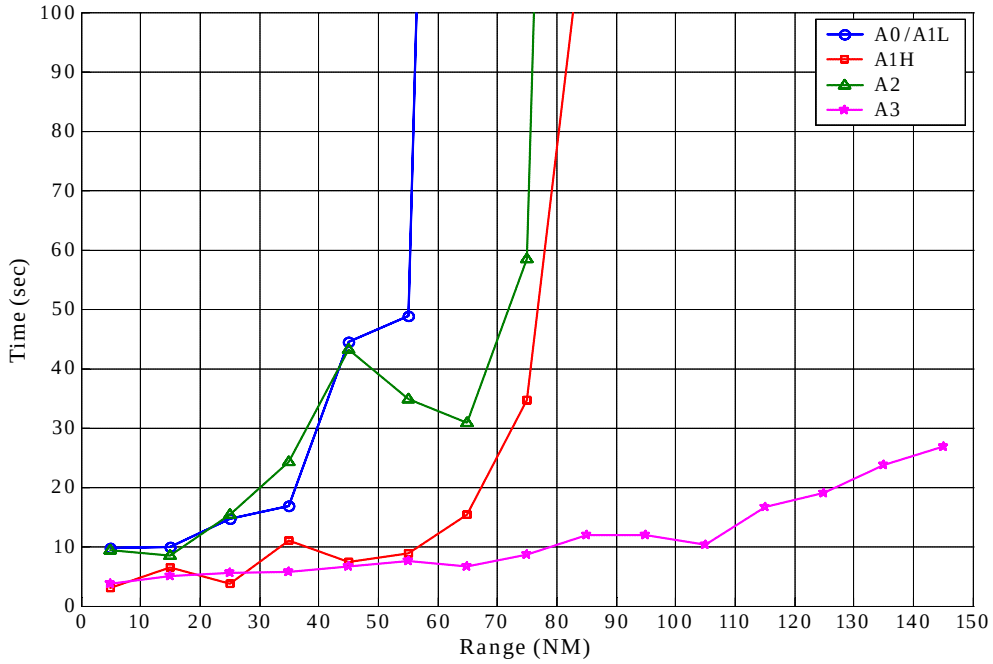

Figure 10 - Maximum Times for an A2 Receiver on the Ground at Brussels in CE 2015 to Identify Transmitter Equipages

Figures 9 and 10 show something not entirely expected for the maximum time to identify the A2 transmitters. For the 30-40 and 40-50 NM range bins, the A2 transmitters perform similar to or worse than the A0/A1L transmitters. This is due to the combination of the algorithm for identification and the way the maximum time is calculated. The A2 transmitter is identified by at minimum two unique messages being received, whereas the A0/A1L transmitter only requires a successful decode of message type 2. The times plotted in Figures 9, 10, 3 and 4 is the maximum time over 100 trials for each transmitter of that equipage type within that range bin. A transmitter can have 99 times of 5 seconds, and one time of 100 seconds, and the 100 seconds is captured for the maximum time.

For example, in the 30-40 NM range bin in Figure 9, there is an A2 transmitter from the 3rd CE 2015 scenario that has a mean MSR for all transmissions of .48. The most common way to identify an A2 is by receiving both type 4 and type 1 messages. However, the MSR values for the type 1 messages from this particular transmitter are not equal to one until 45 seconds have elapsed, meaning that over 100 trials, there is a possibility that no type 1 messages are received until the max. time from Figure 9 of 45 seconds. This is what is captured in the Figures. The behavior settles out as the ranges increase.

T (sec)	3.8	8.9	13.3	14.9	19.7	24.5	29.5	30.5	35.3	40.3	45.4
MSR	0.1	0	0.2	0	0	0.9	0.4	0	0	0	1

Table 1 - Times and MSR Values for Type 1 Messages from A2 Transmitter that Sets Maximum ID Time in 30-40 NM Range Bin in Figure 9

Figure 11 shows the fraction of unknown transmitter equipages by transmitter equipage type. –1 corresponds to A1L equipage. No A3's out to 150 NM (the cutoff) were unidentified.

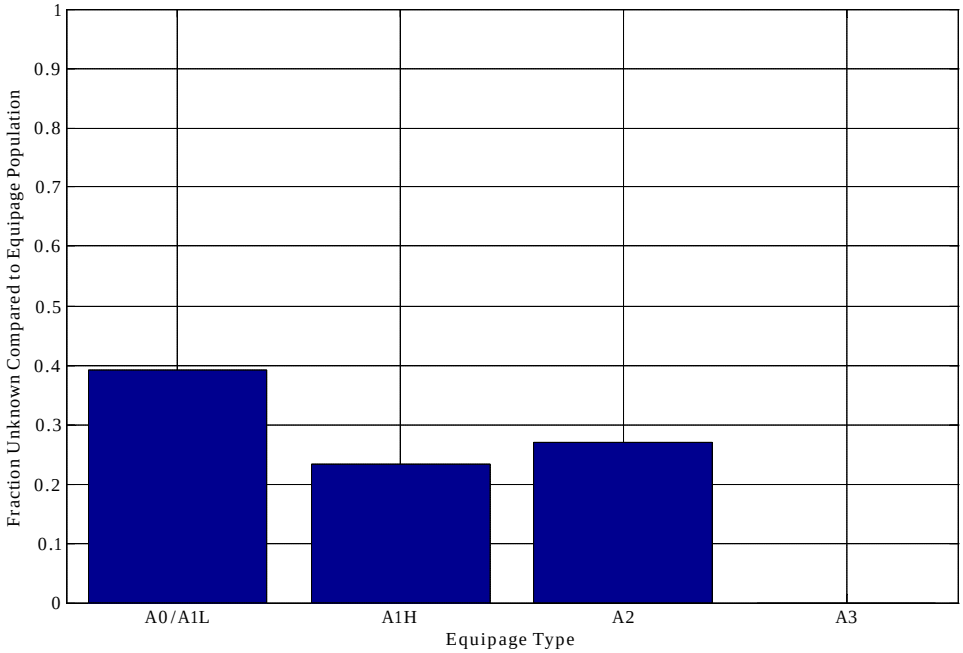

Figure 11 - Fractions of Transmitters Not Identified by a Ground Aircraft Receiver

Figure 12 shows the fraction of unknown transmitters as a function of range from an A2 receiver located on the ground at Brussels. No aircraft are unidentified at 70 NM or less. There are no unidentified A1H and only one unidentified A2 transmitters at ranges less than 100 NM, and no A3's are unidentified.

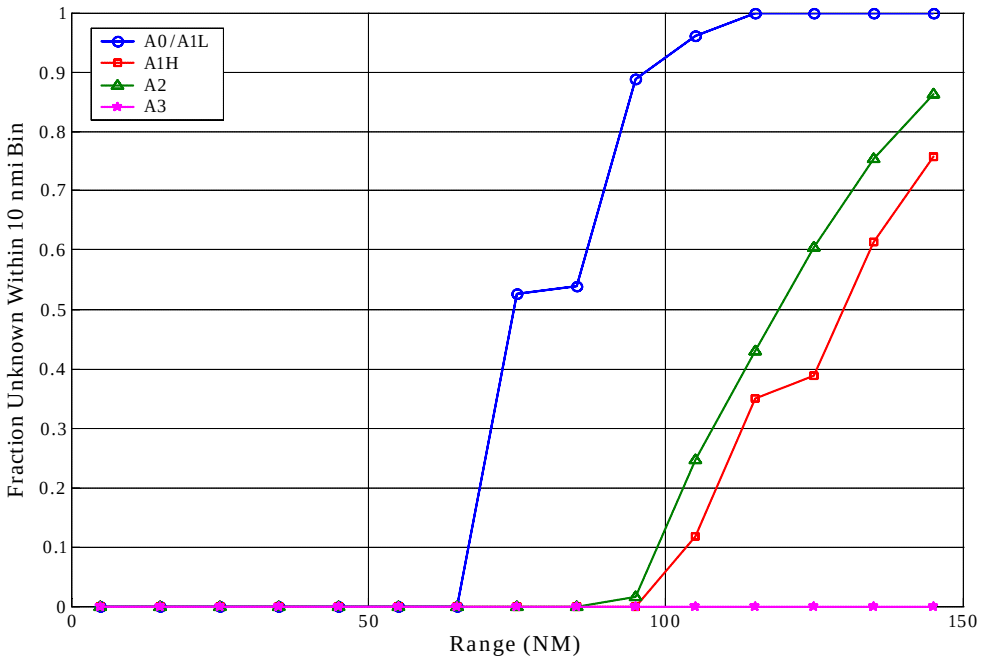

Figure 12 - Fractions of Unknown Transmitter Equipages by Range for an A2 Receiver on the Ground at Brussels